# Pollution over megacity regions from the Tropospheric Emission Spectrometer (TES)

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TES measures air quality

- **January 2013**: megacity observations start
  - **simultaneous closely spaced observations**
  - **(~ 12 km apart)**
  - **O_3, CH_4, CO_2, NH_3, CH_3OH, HCOOH, PAN**
  - **quantify urban pollution production, transformation and export.**
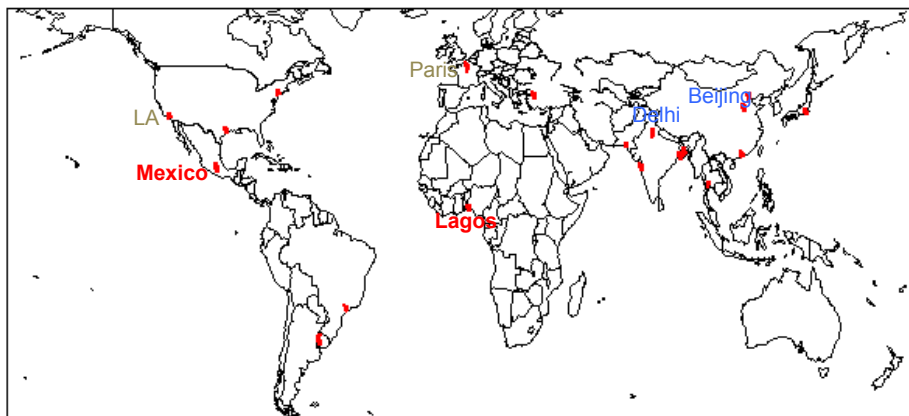
City	Lat	Lon
Bangkok	13.6383	100.304
Beijing	39.8543	116.386
Buenos Aires	-34.7112	-58.9112
Delhi	28.957	77.4496
Dhaka	23.6374	90.1974
Houston	29.7203	-95.2691
Istanbul	40.9605	29.1336
Karachi	24.6877	66.7348
Kolkata	22.5168	88.4081
Lagos	6.57795	3.25456
Los Angeles	34.0724	-118.146
MexicoCity	19.1627	-99.2384
Mumbai	18.8821	72.8437
New York City	40.7045	-73.9673
Paris	48.8499	2.37268
SWChina	36.9589	114.249
Sao Paulo	-23.5372	-46.6846
Shenzhen	22.3653	113.674
Tokyo	35.5149	139.425

# Model summary

GEOS-Chem

- **Western Africa**
- **High resolution: 0.5x0.667 deg**
- **Includes NH_3 from**
    - biomass burning (GFED4)
    - anthropogenic activity (EDGAR)
    - biofuel and charcoal
    - trash burning
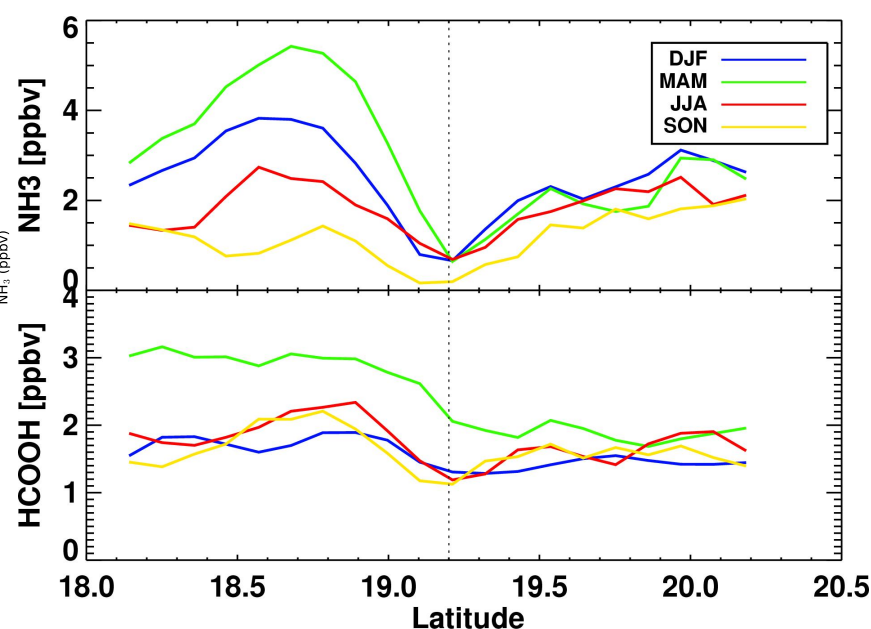- **Only secondary HCOOH production**
- **Fixed CH_3OH**

MIROC-Chem

- **Mexico**
- **Lower resolution: 2.5x2.5 deg**
- **Focus on accurate O_3 chemistry modeling**
- **Limited NH_3 emissions**
- **No separate modeling of HCOOH**
- **Variable CH_3OH**

NH$_3$ and HCOOH near Mexico City

TES MAM NH$_3$transect
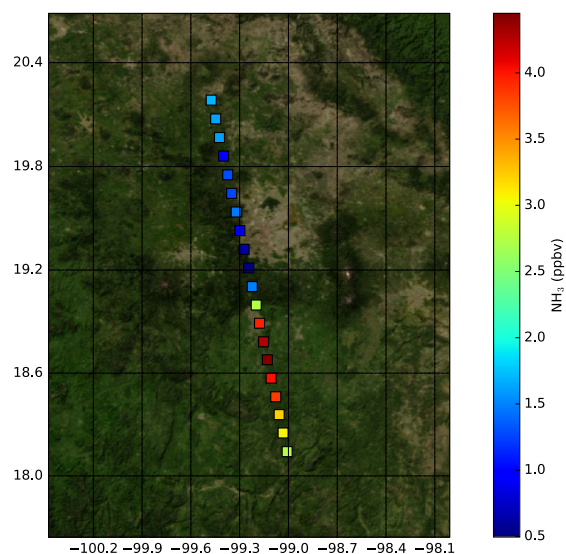
TES Seasonal means

TES NH$_3$ peaks to the south, especially in DJF and MAM

TES HCOOH peaks in same region in MAM

Fire source?

Focus on air quality near the surface:
➔ will use means of TES data over the first two or three layers above the surface

Biomass burning in Mexico

Biomass burning is strong over the Yucatan in the NH spring
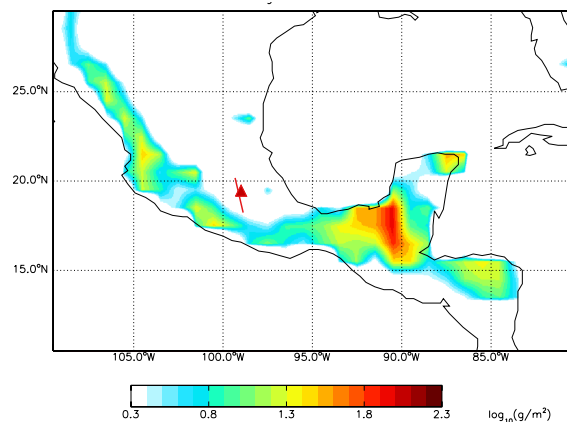
Mean May GFED C emissions (1997-2010)
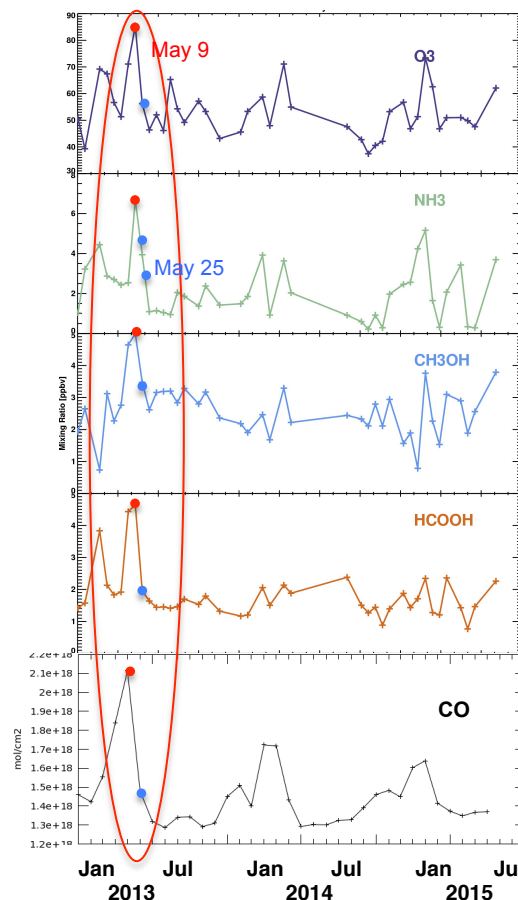
TES transect means

Concomitant biomass burning products (TES methanol, formic acid, ammonia**) and CO (from AIRS) suggest that strong** fires might **contribute significantly to** pollution in the Mexico City area **during the BB season**

Possible BB sources

May 9

May 25

FIRMS fire counts

HYSPLIT four day back trajectories
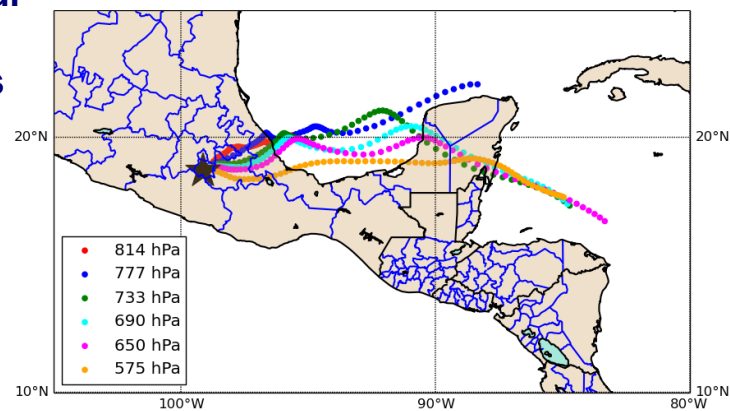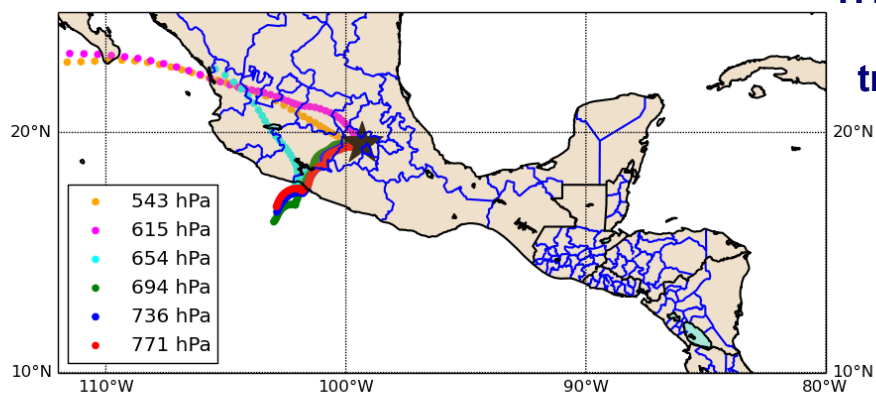
May 9 vs May 25

TES single transects
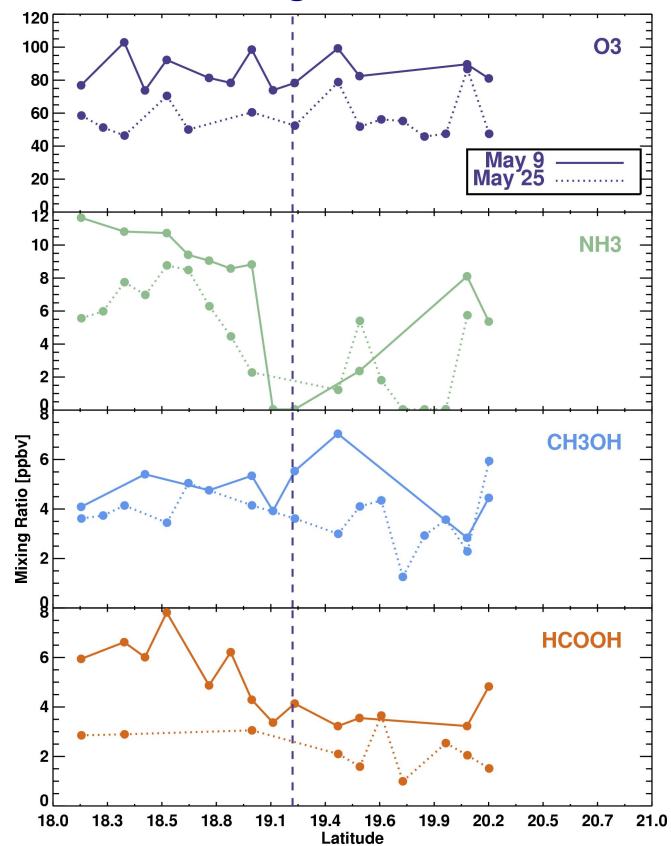
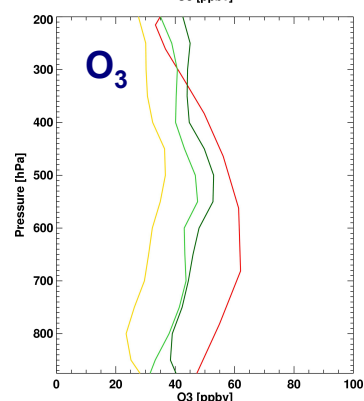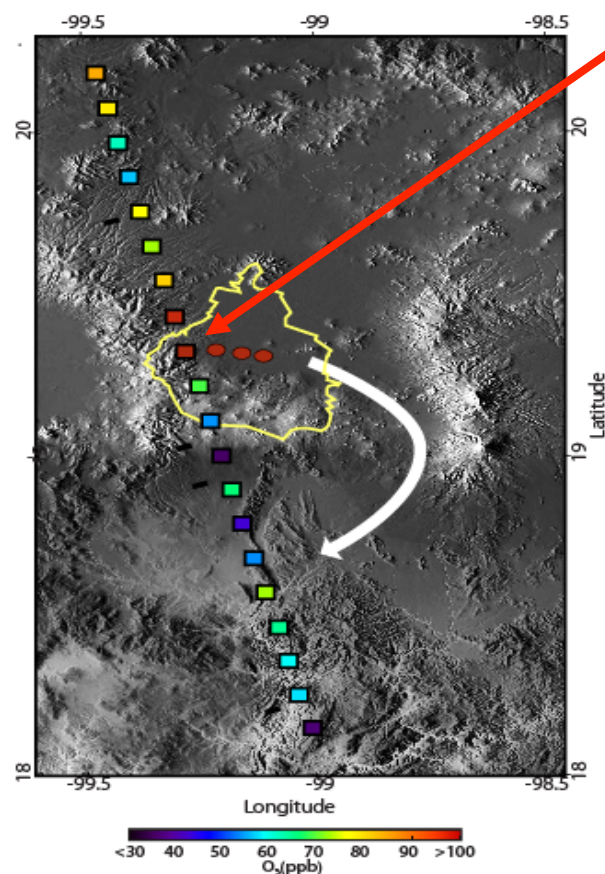## TES and MIROC mean profiles along transect
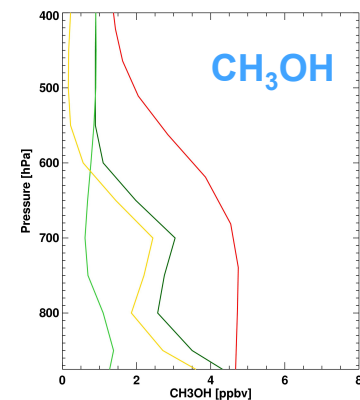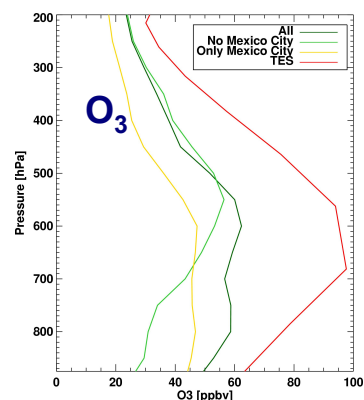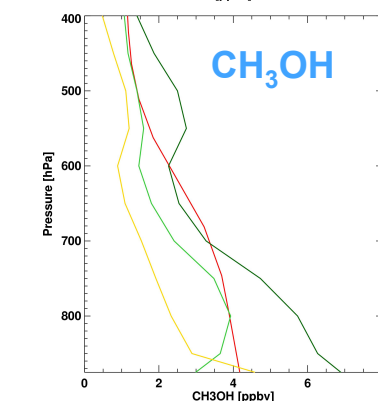
Mexico City October pollution event

Megacity Pollution: The jointly retrieved TES/ OMI near-surface ozone product shows very high ozone (~120 ppb) in Mexico City on a day with stable, stagnant air in the boundary layer.

TES carbon monoxide, methanol, & formic acid (ozone precursors) are also elevated, as is the nitrogen reservoir peroxyacetyl nitrate (PAN)
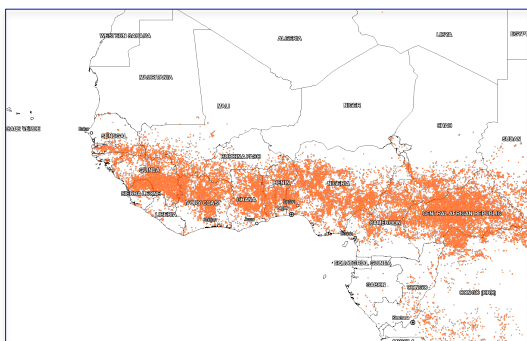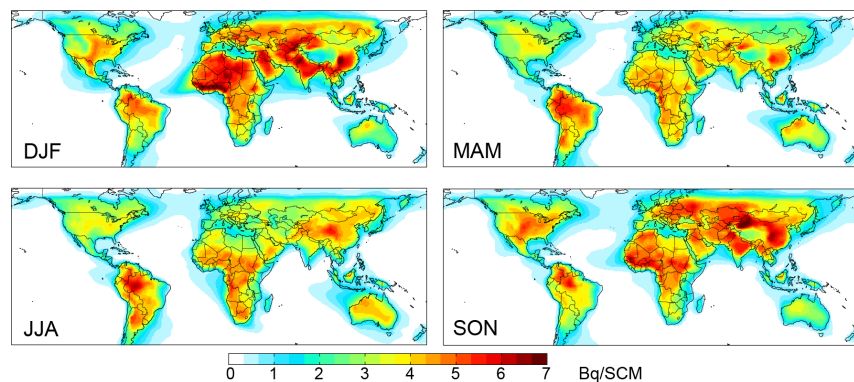
AIRS-OMI O_3
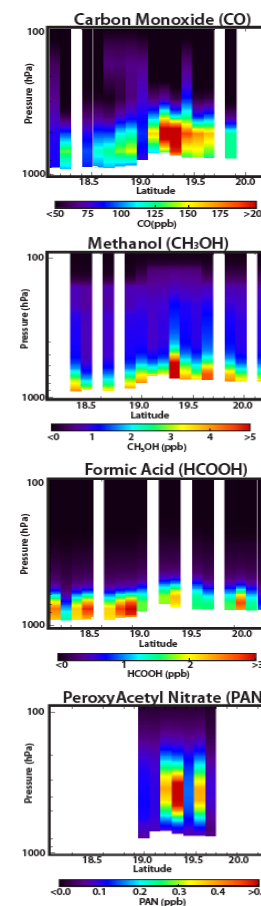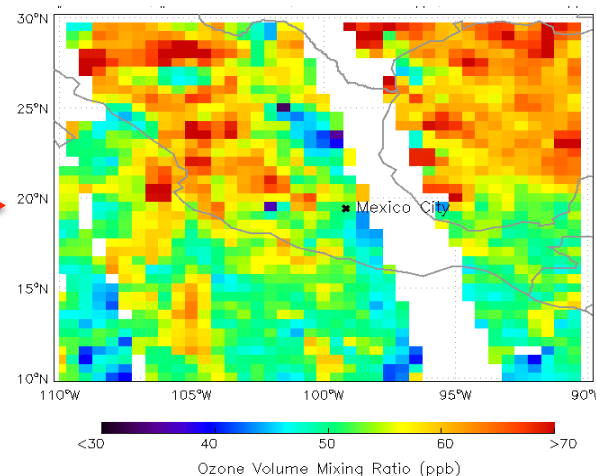
Western Africa- Lagos

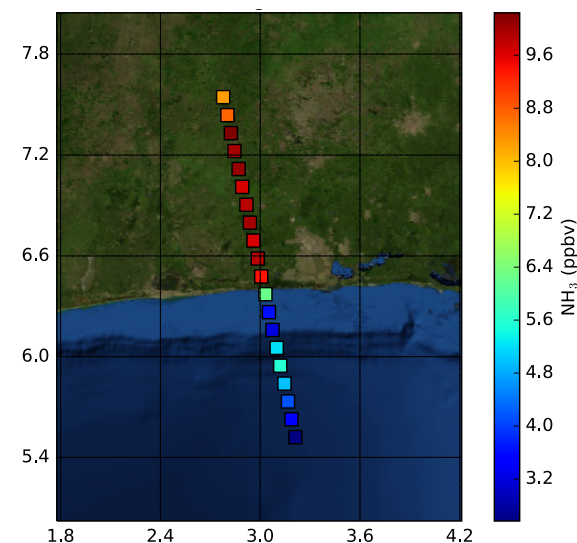**Western Africa has one of the strongest biomass burning seasons (December-March) on Earth**

TES DJF NH$_3$ transect

**Fire counts
Jan 28-Feb 9, 2013**

GEOS-Chem ^{222}Rn simulation

High ^{222}Rn in DJF due to stagnant air conditions

High pollution in DJF

NOAA HYSPLIT MODEL
2013-01-28 00:00:00 through 2013-02-07 00:00:00
GDAS Meteorological Data
Source: (7.12° N, 2.87° E)

- 625 hPa
- 705 hPa
- 794 hPa
- 892 hPa
- 943 hPa
- 986 hPa
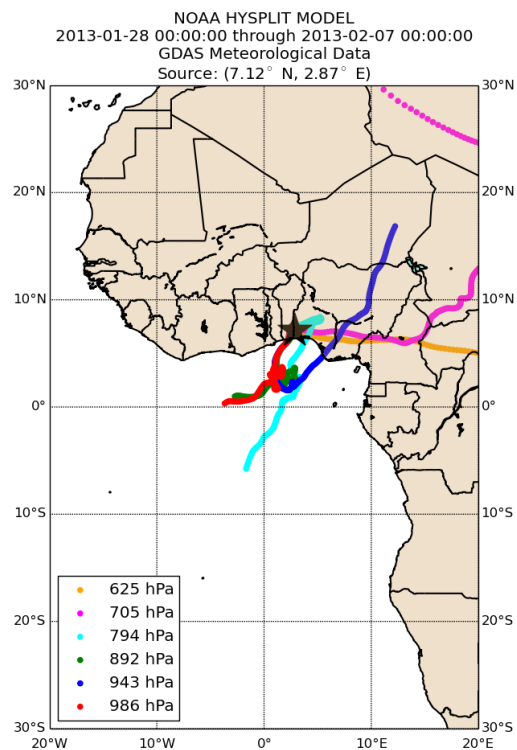
Slow circulation – reduced venting

Pollution sources
- **Biomass burning**
- **Petrochemical**
- **Two-stroke engines**
- **Generators**
- **Trash burning**
- **Traffic**

Sea breezes play important role

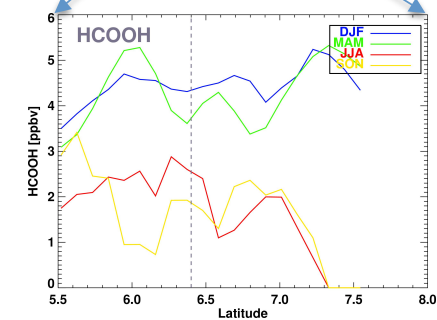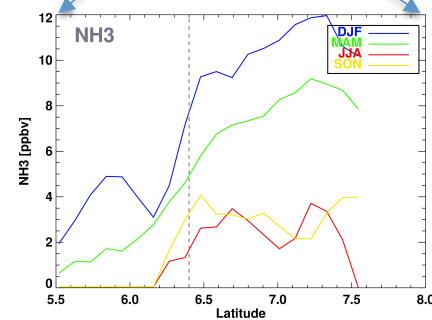**2015 El Nino may have also been influential**

TES transect means

O3

NH3

CH3OH

HCOOH

Lagos
Mexico City

Mixing Ratio [ppbv]
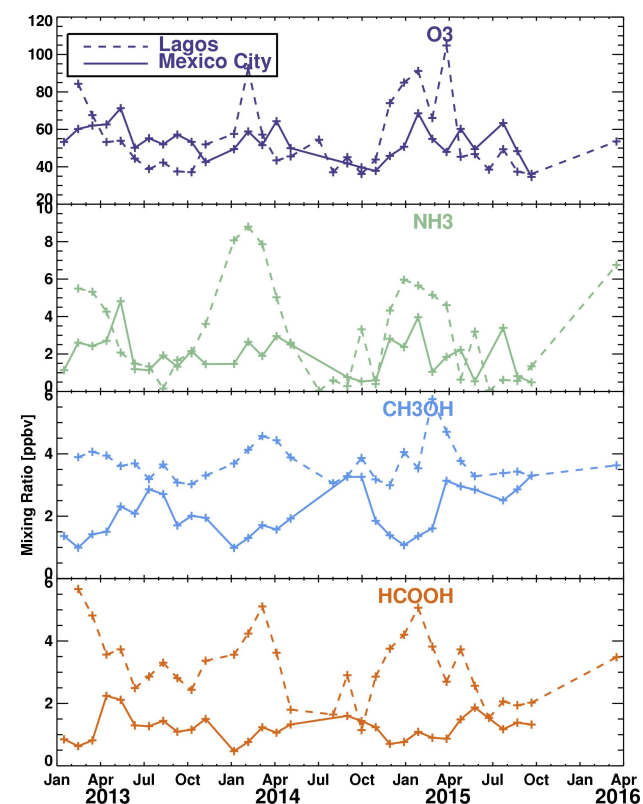
Seasonal Means

Ocean ← → Land

**GEOS-Chem
2006
1000-700 hPa mean**

**TES
2013-2015**
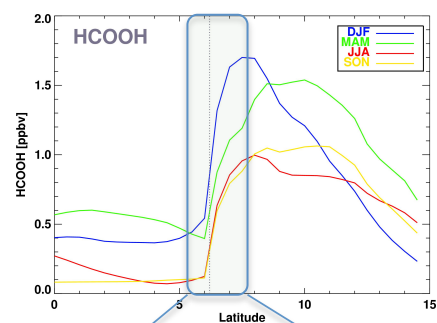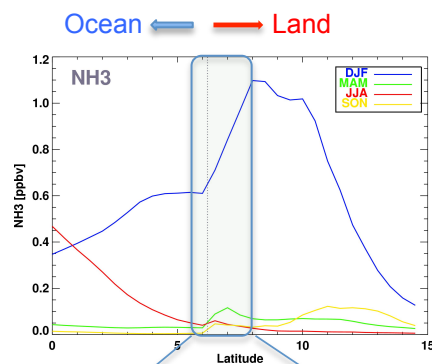
GC:
- **higher values in DJF**
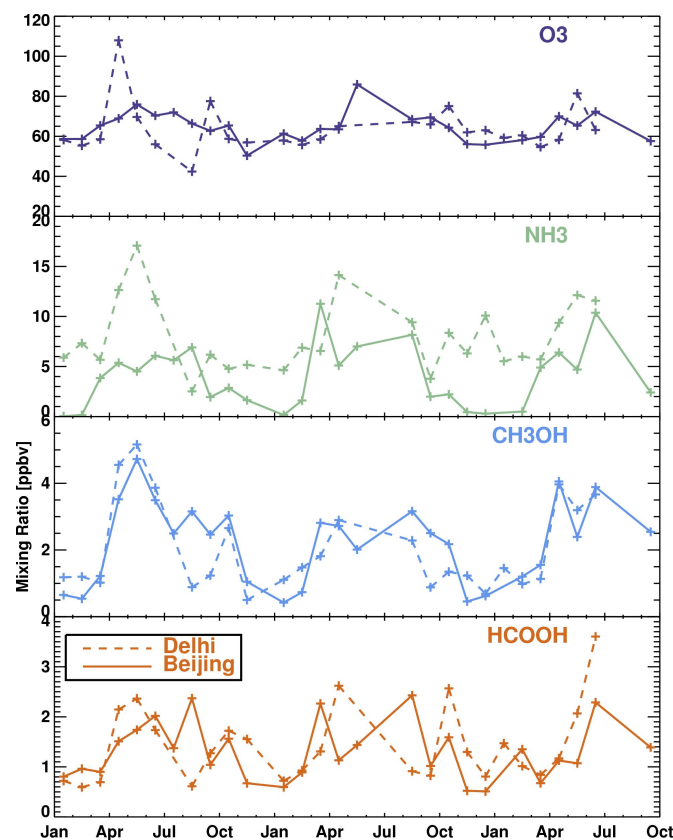- **sharp ocean/land gradients**

TES:
- **high values in DJF and MAM**
- **no gradient in HCOOH**
- **moderate NH$_3$ over ocean in DJF and MAM**
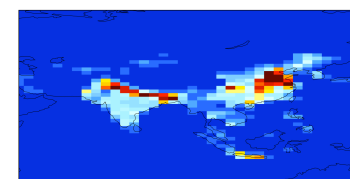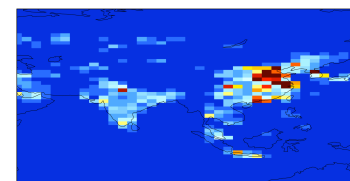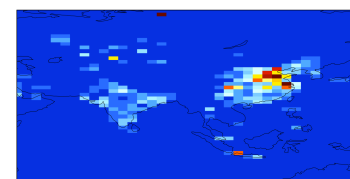- **→ weak circulation - stagnation**

A Tale of Two Cities

Beijing

Delhi

- Similar **O3 and CO** levels
- Why is **NH$_3$** different?

NH$_3$

NO$_x$

SO$_2$

ECLIPSE v5 emissions

Summary

- **TES has collected data from January 2013 to April 2016 over 19 megacities**

- **Data are closely spaced (12 km) and are taken approximately every two weeks**

- **Species measured: O_3, CH_4, NH_3, CH_3OH, HCOOH, HDO, PAN, CO_2**

- **Data point to influences of biomass burning and other pollution sources**

- **Also show different chemistry regimes in different cities**

- **On going work uses the new AIRS-OMI O3 product to provide context for interpreting the TES megacity measurements**
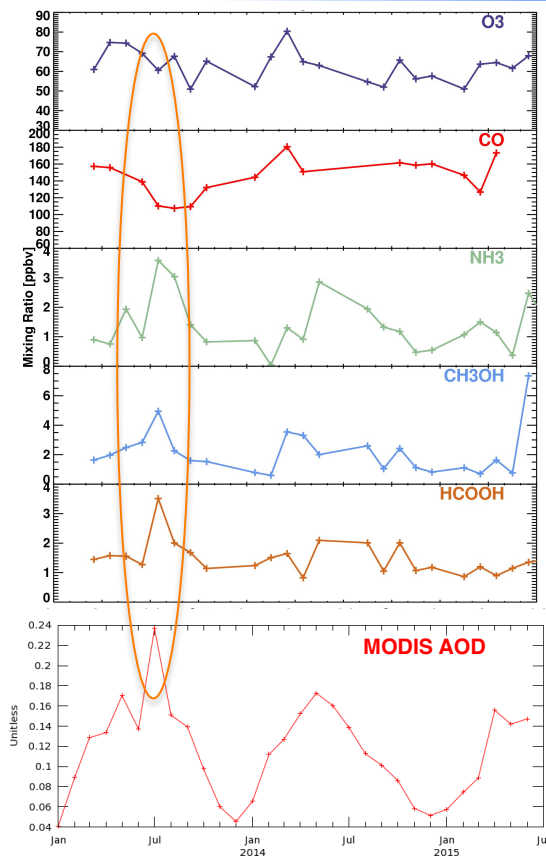
- **Data are available on AVDC**
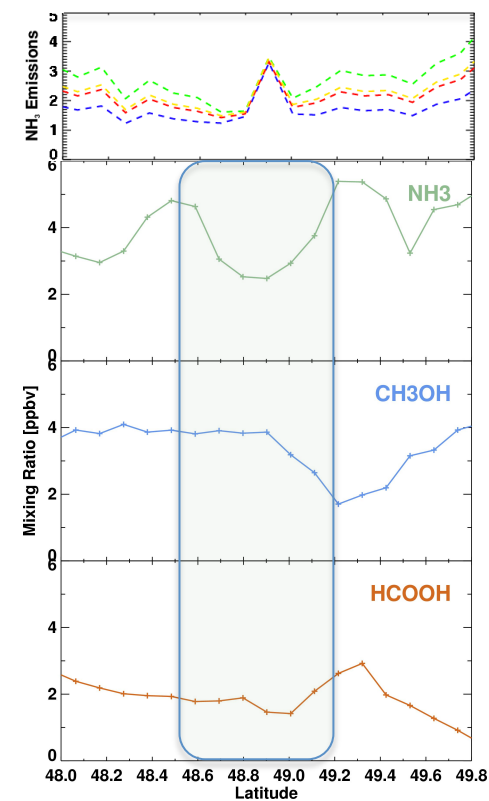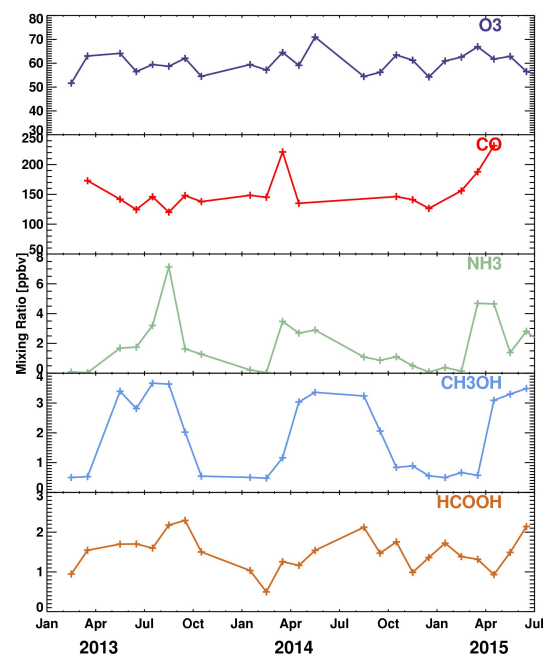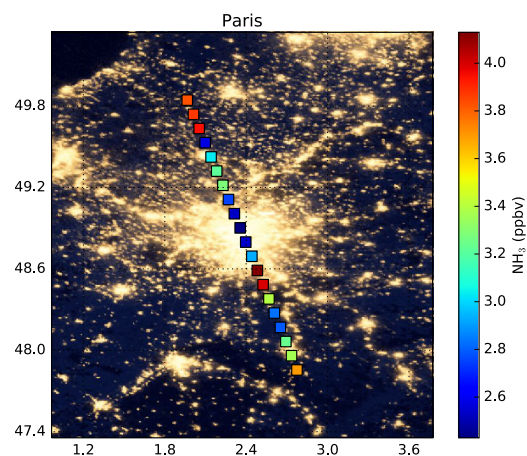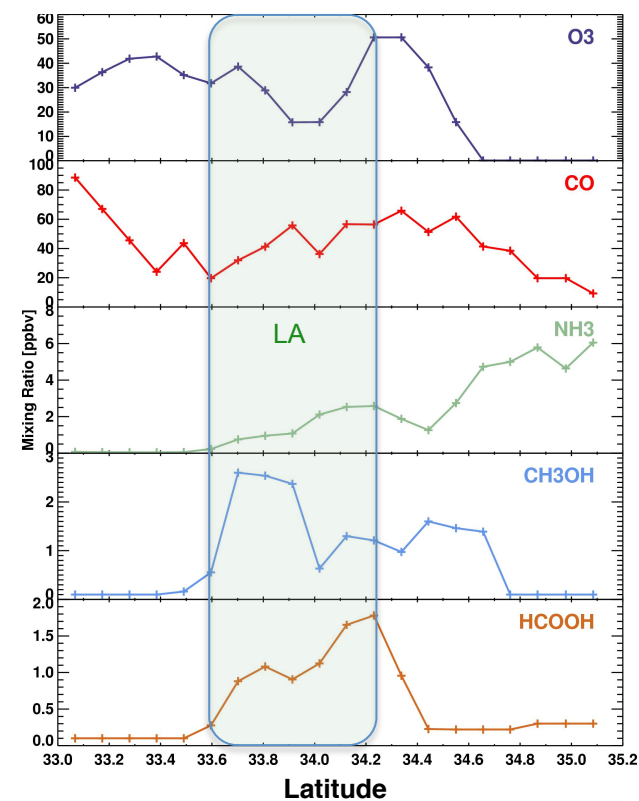
Paris

HTAP and TES disagree on source of NH$_3$
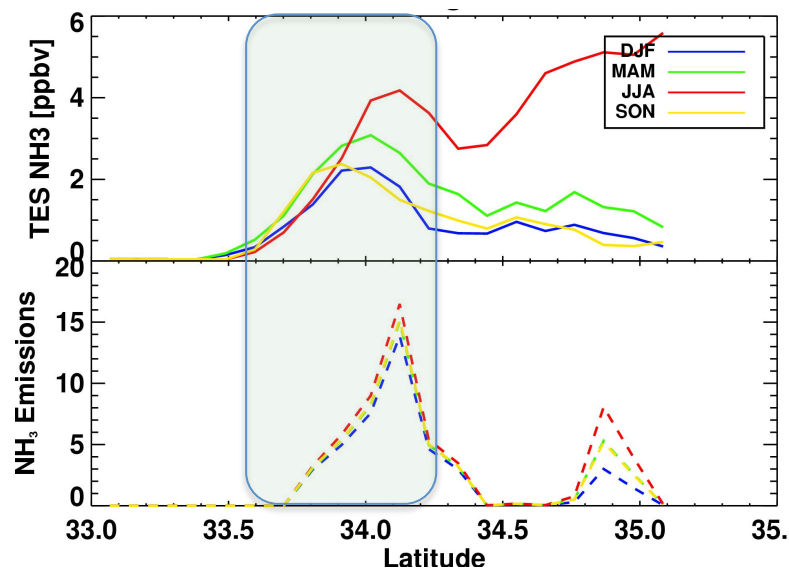
JJA Seasonal Means

Los Angeles puzzle - 1

High NH$_3$, CH$_3$OH and HCOOH in July 2013 correlate with higher AOD, but not with CO or O$_3$

- Early fire season
- But not from fire?
- HCOOH, CH$_3$OH generated locally over LA
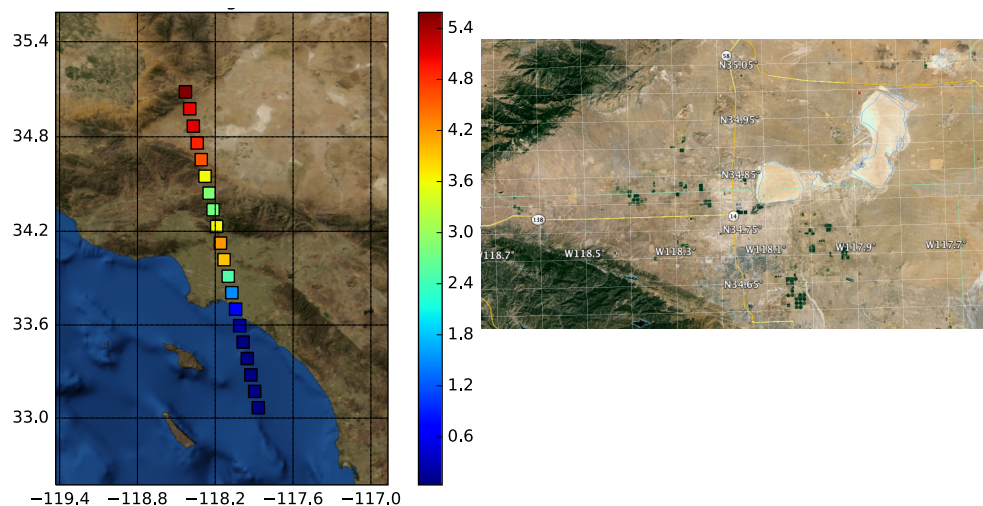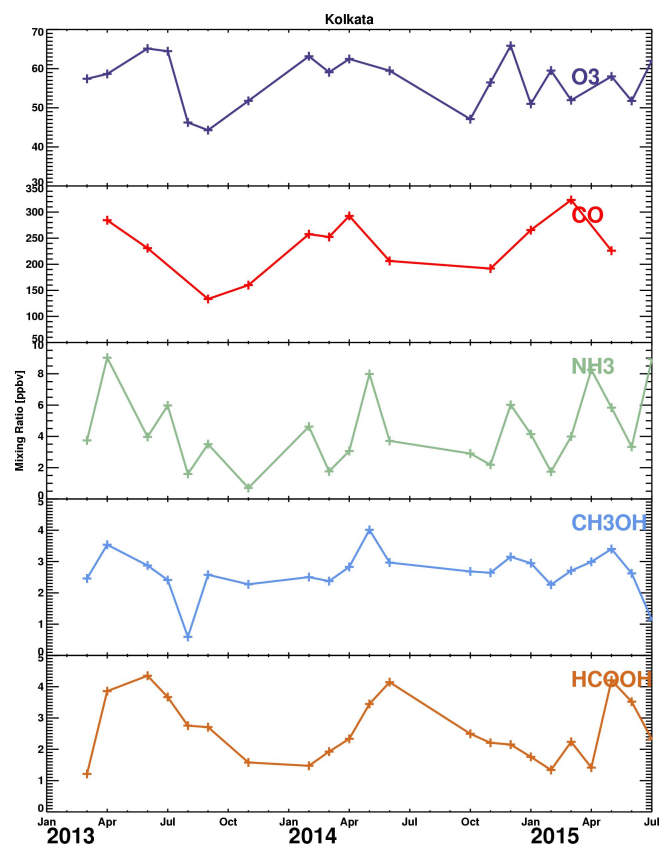- NH$_3$ has different source

August 2013

Los Angeles puzzle - 2

High JJA TES peak north of the city
→ **HTAP underestimates NH$_3$ emissions here**

TES JJA NH$_3$ transect

TES NH$_3$ and HTAP emissions peak within city
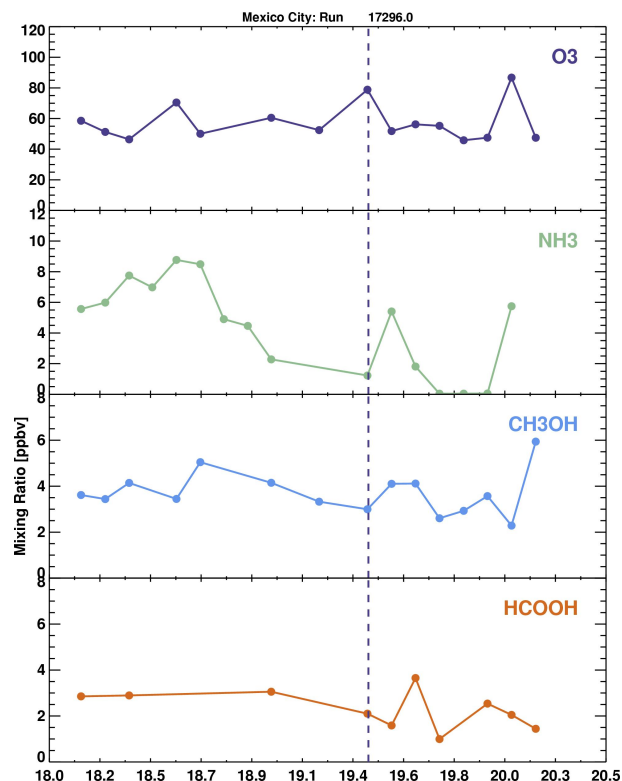
Kolkatta

May 25 – Lower pollution

- Lower HCOOH is consistent with less transport over fires
- Model O_3 profile points to mix of local production and transport

- High HCOOH and NH3 south of city point to BB influence there
- Lower HCOOH further north city suggests transported BB is not major contributor
- Model O_3 profile points to local production